SOLVE-II Flight Report: Thursday, 01/09/2003

Written by Paul A. Newman with contributions from Rennie Selkirk

Flight Type: Transit Flight

Flight Objectives:

1. Get to Kiruna
2. 10 hour straight flight for the lidars.
3. Scan tracers from mid-latitudes to polar latitudes.
4. Map latitudinal extent of El Reventador stratospheric volcanic plume.
5. 10 hour sleep for the project scientist

Flight Plan:

00:31 – Takeoff
10:30 – Landing

Forecast Meteorology:

At 00Z on January 9th, a tropospheric ridge has built over western North America with the jet stream pushed northward to the US/Canada border region. Maximum WNW winds in the jet at FL370 will exceed 110 kts as the DC-8 traverses the tropopause The DC-8 transit flight track will cross into the stratosphere near Shelby, Manitoba as the flow weakens to 30-50 kts in more northwesterly flow. As the track crosses Baffin Island and then Greenland the flow will weaken even more. Off the east coast of Greenland and into the Norwegian Sea, the track will pass through somewhat moister air that is experiencing weak ascent on the backside of shortwave ridge, although it will remain in the stratosphere until the final descent into Kiruna.

The lower stratospheric polar vortex is elongated and displaced into the eastern hemisphere. The DC-8 will pass under the vortex after passing over Greenland. Temperatures between Kiruna and Greenland are cold enough for the formation of PSCs.

Surface forecast for Dryden, Wednesday afternoon: Partly cloudy. Highs 60 to 69° F. Northeast winds 10 to 20 mph.

Surface forecast for Kiruna on Thursday - Overcast. High: 17° F. / -8° C.

Flight Meteorology:

Flight Report:

The DC-8 took off at 00:35. On ascent, FastOz reported some very high ozone values (in excess of 100 ppbv). These high values were consistent with the expected lower stratospheric filament seen in the lower altitude PV charts (e.g., 320-340 K).

The sun was below the horizon by 01:02, but looked nice. AROTAL had a bit of a problem with its chiller.

We initially leveled off at 33kft. Winds were 40-45 kft SW, ozone was about 60-80 ppb, Tropopause was at 13-14 km (45 kft).

As we proceeded northward (43°30'N), ozone showed interesting variations of values from values near 70 ppbv to over 100 ppbv over distances of a couple hundred km. This layer of air was very dry, showing only small variation from about 15 ppmv. Winds were pretty consistently SW, but with values of less than 30 kts. MTP showed a variation of the vertical profile near the flight altitude, suggesting that we were in an older layer of stratospheric air.

By the time we reached the Idaho-Montana border (46°N) around 02:10 UT, the winds had come around to SW at about 40 kts, but starting to come around to W. Ozone was still showing the large fluctuations, and water was up around 18 ppmv. By 47°25'N, winds had picked up to 56 kts W.

We crossed the Canadian border (49°N) and winds had picked up to 90 kts W. Some slight turbulence in this same region. By 49°55'N, winds were up to 105 kts WNW. DIAL observations showed that the ozone isopleths were slowly descending. The tropopause was also showing a steady downward change as we moved towards the core of the jet. At 50°45'N, winds had increased to 126 kts WNW. The core of the jet was at approximately 51°N. Ozone, CO, and H2O showed a lot of structure in this region, and we again got a bit of turbulence near 51°25'N. By 51°30'N, ozone was over 200 ppbv, H2O save about 10 ppmv, and wind speeds were beginning to drop off (112 kts at 300). MTP was using the wrong retrieval coefficients, Panther also showed drops of F11, methyl chloroform, and carbon tet. Hence, we crossed into the stratosphere at about 02:52Z.

DIAL reported Arctic haze below the aircraft at an altitude of 2 km near 52°20'N. As we crossed the jet, there were layers of ozone below us that were correlated with particles.

Figure 1. Ed Browell next to his DIAL ozone and aerosol lidar on the SOLVE-II DC-8 flight of January 9, 2003.

North of the jet (53°15'N), the tropospheric ozone below the plane became quite clean. At flight altitude DLH water was at values of 4.5 ppmv, while ozone was above 300 ppbv. Winds had fallen to below 80 kts NW.

As we transitioned to 37 kft, ozone jumped dramatically to over 500 ppb. As we continued northward, these values fell off as temperatures decreased and we slowly moved to lower potential temperatures.

Winds died off pretty completely over Canada. Near Baffin Island, winds at 37 kft were negligible. We reached the coast of Greenland at about 07:00Z. Outside air temp was about -58°C, while ozone was 320 ppb, H2O was about 4.4 ppmv, and CO was about 37 ppb. MTP showed reasonably cold temperatures ~200 K near the coastline of Greenland. These temperatures became colder as we progressed across Greenland.

Over North-central Greenland, MTP showed extremely cold temperatures around 190K near 26 km, but no PSCs were evident in the DIAL data. Temperatures at altitude were near about –60°C, while winds were still quite light. Water vapor was slightly higher at about 5.3 ppmv, while ozone had fallen somewhat to 260 ppb. Because of the colder ambient temperatures at these latitudes and altitude (37 kft), we were only flying at about 328 K.

Hit the eastern coast of Greenland at about 08:20Z, but ***no sign of PSCs***, in spite of the cold temperatures (< 195 K) observed by MTP at altitudes above 20 km. However, ozone decreased steadily as we continued along our track, suggesting that we had moved below the lower stratospheric polar vortex. At flight altitude (37kft) the potential temperature was about 321K, reflecting the ambient temperature of about –65°C. Winds were about 20 kts NW, giving us a fair tail wind into Kiruna. MTP showed a tropopause that was only a couple of thousand feet below us at about 10.5 km. This high tropopause was reflected in the DIAL observations, which showed a sharp transition of ozone.

At about 08:45, DIAL began to see a layer of enhanced scattering at an altitude between 15-16 km. This layer was very extensive, but apparently non-depolarizing. MTP showed a temperature of about 200K near this altitude. At about 09:05 we also saw a couple of very brief PSCs at an altitude near 20 km. The horizon to our east was nice and bright, showing what appeared to be a PSC ahead of us. We began to see two thin layer PSCs at about 18.5 and 21 km at about 09:10Z. These PSCs had some depolarization, suggesting that they were type 1a PSCs.

Figure 2. Sunrise on January 9, 2003 taken from the DC-8 as we approached the Norwegian coastline. The faint white cloud above the horizon on the right of the image is a polar stratospheric cloud. Probably a type Ia PSC.

By 10:00Z, the sun was above the horizon, and we were preparing to begin our descent into Kiruna. At this point, winds were about 30 kts NE, and the outside temperature was -64°C. Theta was 324K, with ozone near 300 ppbv, water about 4-5 ppmv, and CO near 33 ppbv. It was pretty clear that we were in the stratosphere from the near the Canadian border all of the way to Kiruna.

Pilots: Bill Brocket, Craig Bomben
Navigator: Russ Pedula
Mission managers: Chris Miller & Bob Curry
Mission scientist on board: Paul A. Newman.

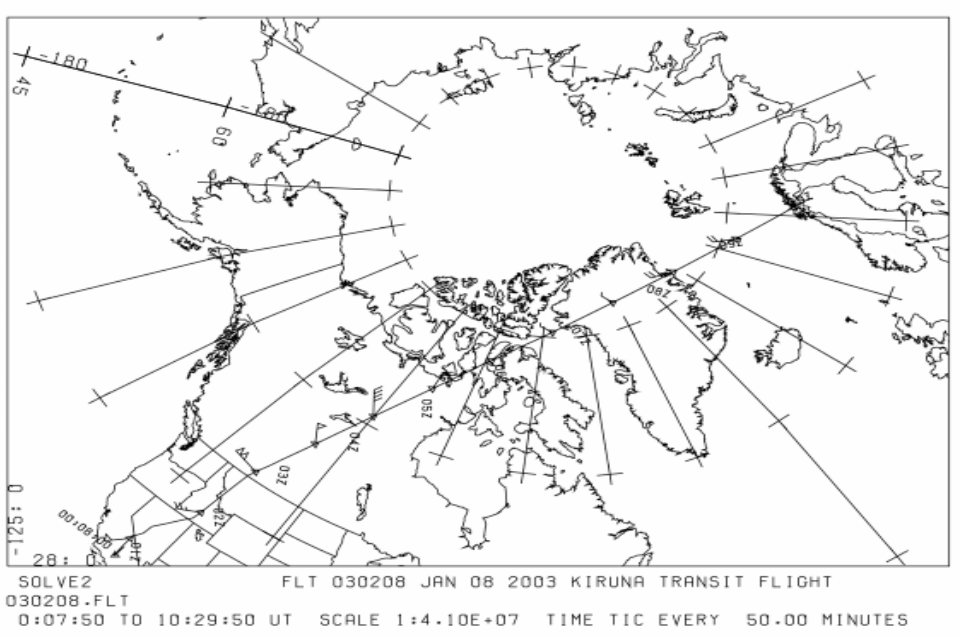

Figure 3. Aircraft flight path with wind vectors (kts). Flags represent 50 kts; full barbs are 10 kts, 1/2 barb represent 5 kts.

Status Report: Instrument – PI

DIAPER (in situ aerosols) – Anderson
Good flight, had some problems with SP2.

FastOz – Avery
Good flight, interesting transit. Ozone got to 550 ppbv.

DIAL (Lidar ozone and aerosol above and below the AC) – Browell
Great flight. Saw a lot of things both above and below us.

DACOM/DLH (in situ trace gases and open path water vapor) – Diskin
Generally good flight. DLH worked. Continued problem with N2O.

PANTHER (in situ PAN and other trace gases) – Elkins
Good flight, until about 7Z when inlet became clogged.

MTP (microwave temperature profiler) – Mahoney
Pretty good flight.

AROTAL (Lidar ozone, aerosols and temperature above the AC) - McGee/Hostetler
Problem with chiller compressor at the start of the flight. Didn't work over the entire course of the flight.

GAMS/LAABS (solar occultation ozone, aerosols and oxygen A band) – Pitts

Didn't run the instrument.

DIAS (Direct beam solar irradiance) – Shetter
Didn't have any sun, so didn't operate.

FCAS/NMAS (in situ aerosols) – Reeves
Good flight.

AATS-14 (sun photometer) – Russell
Failed.

Differential GPS – Muellerschoen
Everything worked smoothly.

ICATS
Excellent flight. Everything worked smoothly.

Plots (flight plan, solar zenith angles, Rel. humidity):

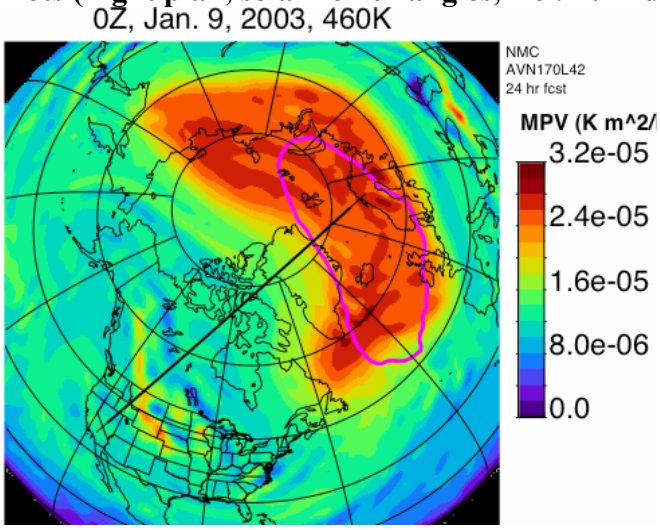

Figure 4. Flight track from Dryden to Kiruna. Polar vortex first encountered over Greenland, below vortex after passing Greenland.

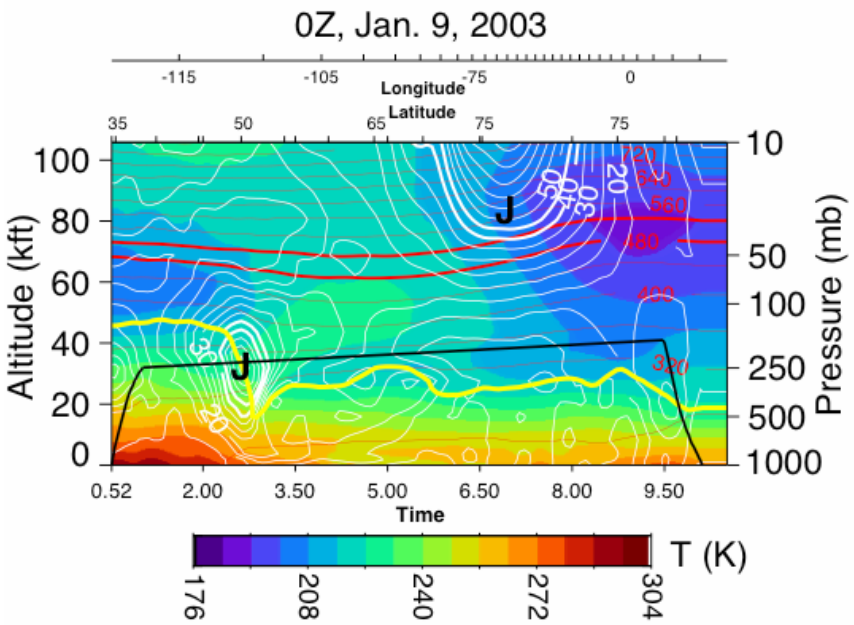

Figure 5. Curtain file showing flight track from Dryden at left to Kiruna on the right. Lat/Lon axis is indicated at the top. Core of subtropical jet encountered immediately north of Canadian border at about 50°N. DC-8 should encounter winds of 110 kts and pass from tropospheric to stratospheric air at this point. Core of polar night jet is located near 75N. Temperatures cold enough for PSCs are shown as purple color.

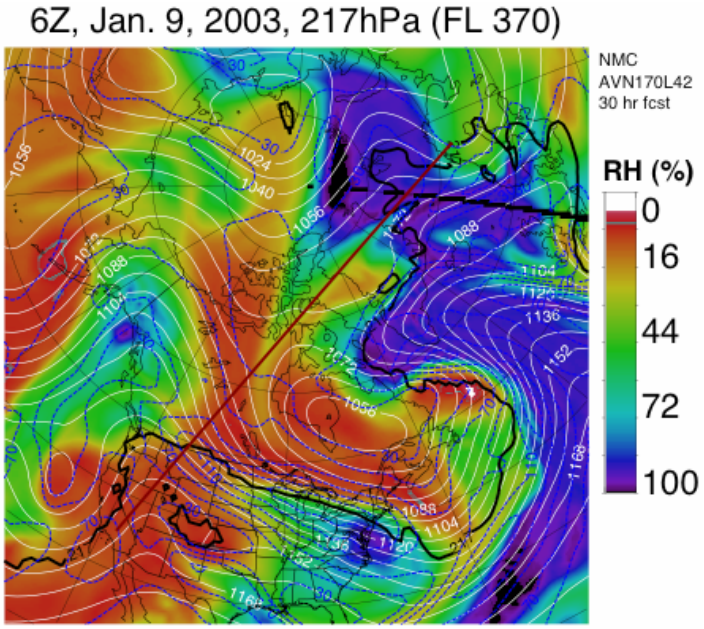

Figure 6. Relative humidity at FL370. Height contours are shown in white (winds blow parallel to height contours), isotachs are shown as the dashed blue contours, and the tropopause is shown as the thick black line. DC-8 Track is indicated by the thick brick-red colored line. DC-8 crosses the entrance region of the subtropical jet near the Canadian border (see convergence and tight packing of white height contours, and large values of blue colored isotachs).

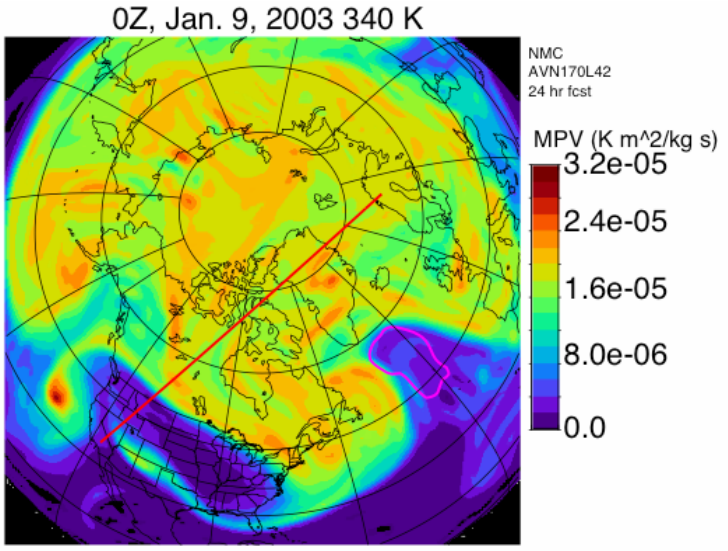

Figure 7. Mpv field at 340K, approximately 33 kft. The PV filament was near approximately North Central Nevada, and fell off over Idaho and Montana.

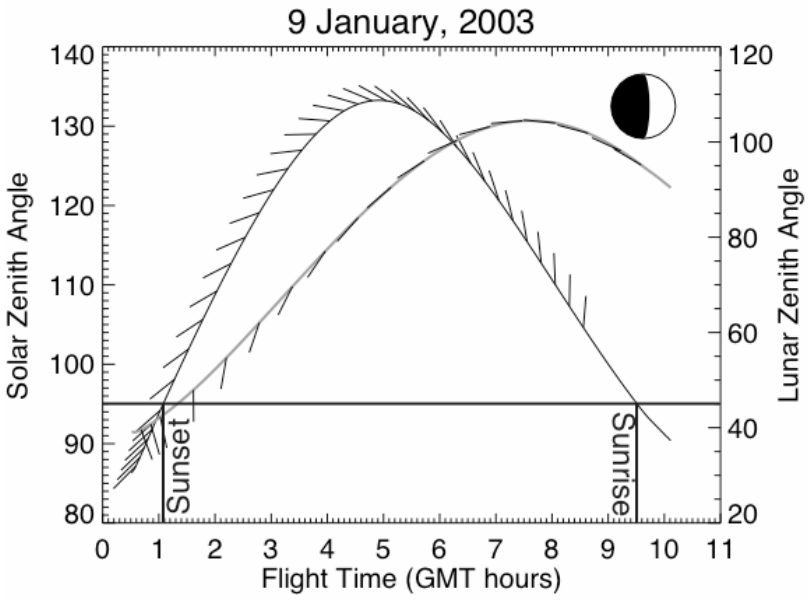

Figure 8. Solar (black) and lunar (gray) zenith angles for the DC-8 transit flight of January 9, 2003 from Dryden to Kiruna, Sweden. Sunset occurs approximately 30 minutes after takeoff, and sunrise is about 45 minutes prior to landing.